VUF-1012
FINAL REPORT

VELA UNIFORM

PROJECT SHOAL

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FALLON, NEVADA
OCTOBER 26, 1963

ON-SITE HEALTH-AND-SAFETY REPORT

Reynolds Electrical & Engineering Co., Inc.

June 1964 Bernard E. Eubank — Alan W. Ward

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Project Shoal

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Radiological Sciences Department
Health & Safety Division
Reynolds Electrical & Engineering Co., Inc.

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Mercury, Nevada
June 1964

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--William E. Moore, off-site radiological-safety superintendent.

--John P. Shugart, radiological-safety supervisor for Project Shoal.

--John T. Tappan, radiological-safety supervisor for Project Shoal.

--William H. Knoll, laboratory technician for Project Shoal.

Diagrams were by Ronald B. Behunin.

ABSTRACT

Project Shoal was an underground nuclear detonation, for which the Radiological Sciences Department of Reynolds Electrical & Engineering Co., Inc. provided general health-and-safety services, as well as normal radiological-safety functions: detecting, identifying, measuring, locating, recording, controlling, and providing protection from radiation.

Before the test, personnel made radiation surveys and collected and analyzed air samples, thus obtaining measurements of normal, background radiation. Then they took radiation measurements from the environs after the test, and compared these data with preshot radiation levels.

Postshot radiation measurements were obtained in six ways:

--By personnel monitoring with portable instruments.

--By remote monitoring with stationary instruments.

--By collecting airborne dust with trays coated with a sticky substance, and analyzing the dust for radiation.

--By sampling gamma radiation with film badges throughout the area.

--By collecting and analyzing air samples.

--By collecting and analyzing effluent samples from the postshot drill-rig vent-line system.

Radiation at shot time was completely contained; released amounts during postshot drilling were negligible.

General results, per category of radioactivity and method of measuring it, were as follows:

--Alpha Activity. The maximum activity from sticky trays was 5.3×10^{-4} μC per ft^2 of surface. (This amount was found on only one tray; only 11 trays out of 55 had between 1.0×10^{-4} and 2.0×10^{-4} μC/ft^2.) Bioassay results were negative.

--Beta Activity (from Sticky Trays). The maximum activity was 8.7×10^{-4} μC per ft^2 of surface. Two trays had more

than 8.0 x 10^{-4} $\mu C/ft^2$; three had from 6.0 x 10^{-4} to 7.4 x 10^{-4} $\mu C/ft^2$; 22 had more than 1.0 x 10^{-4} but less than 6.0 x 10^{-4} $\mu C/ft^2$.

--Gamma plus Beta (from Portable-Instrument Monitoring). The maximum reading was 50 mrad/hr in air at the drill-rig casing December 17; the next two highest were 16 mrad/hr December 16 and 12 mrad/hr December 19, both at the casing. All other daily maximum measurements were 5 mrad/hr or less.

--Gamma. Results from remote monitoring, area-film-badge analysis, and personnel dosimetry were negative. (Film badges show doses only beyond 30 mR.)

--Activity from Iodine 131. The maximum activity measured from filters in air samplers showed 7.2 x 10^{-3} μC per m^3 of air during the period November 29 to December 1; other amounts were 4 x 10^{-5} $\mu C/m^3$ or less. Iodine concentrations in air released from the drill pipe reached a maximum of 8.0 x 10^{-4} $\mu C/m^3$ on December 17. The total amount of Iodine 131 released into the atmosphere through the vent-line exhaust was 3.3 x 10^{-2} Curies in 18 days, while the greatest amount released in any 8-hour period was about 5 x 10^{-3} Curies (an average based on a release of 1.5 x 10^{-2} Curies between 20:13 on December 14 and 10:00 on December 16).

--Activity from Xenon. The total amount of Xenon released into the atmosphere through the vent-line exhaust was 2.1 x 10^1 Curies of Xenon 131m and 9.2 x 10^1 Curies of Xenon 133.

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PREFACE

The purpose of this report is fourfold:

--To describe the functions and responsibilities of the Radiological Sciences Department of Reynolds Electrical & Engineering Co., Inc. for the Project Shoal event.

--To present data gathered by this department on types, amounts, locations, and durations of radiation resulting from Shoal.

--To tell how these data were obtained: methods used for detecting radiation, for collecting samples, and for getting radiation measurements.

--To describe other Health and Safety Division activities necessary to the project.

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I. INTRODUCTION

A. THE EVENT. Project Shoal was an underground nuclear test detonated near Fallon, Nevada, at 10 a.m. October 26, 1963. It was part of the Atomic Energy Commission's Vela-Uniform Program to develop ways of detecting underground nuclear blasts. Sandia Corporation was the responsible Test Group.

The detonation took place in a deep shaft in granite in an earthquake area, so blast effects could be compared with earthquake effects.

B. FUNCTIONS AND RESPONSIBILITIES OF THE RADIOLOGICAL SCIENCES DEPARTMENT. The Test Group requested through the AEC that Reynolds Electrical & Engineering Co., Inc. (REECo) provide all radiological-protection services. This work was carried out by the REECo Health & Safety Division, Radiological Sciences Department, in coordination with the Sandia technical director's health-physics advisor.

Also, for this event, Health & Safety assigned to Radiological Sciences the responsibility of coordinating and supervising general-safety, fire-protection, and medical services.

1. RADIOLOGICAL SAFETY. The radiological-safety responsibility consisted of the following functions:

--Detecting, identifying, locating, and plotting radiation intensities. (This was done by surveys, remote monitoring, and collection and analysis of effluent, air, dust, and similar environmental samples.)

--Measuring and recording radiation intensities and doses (including bioassay).

--Providing protection from radiation and contamination. (This was done by use of clothing and respiratory equipment, and by prohibiting or controlling access to areas.)

--Controlling the sources and spread of radioactivity and contamination.

--Decontaminating personnel, equipment, and material, and disposing of radioactive waste.

--Maintaining and servicing radiation-monitoring instruments.

2. SAFETY, FIRE PROTECTION, AND MEDICAL AID. Radiological Sciences Department supervisors also coordinated and supervised the Shoal safety, fire-protection, and first-aid activities. (Health & Safety Division aidmen were available full time to give medical treatment.)

Safety, fire-protection, and medical responsibilities were as follows:

--Making weekly fire and safety inspections at the Shoal site and at Fallon offices and warehouses; reporting on hazards; recommending corrections and reporting on their outcome.

--Holding weekly safety talks with field personnel.

--Establishing a volunteer fire brigade.

--Providing training in fire fighting.

--Investigating and reporting on vehicle accidents.

--Providing routine first aid and emergency treatment.

--Providing ambulance service to Fallon.

(See Appendix for breakdown of occupational and non-occupational injuries by type and month.)

II. ACTIVITIES

A. EQUIPMENT TRANSPORT AND PREPARATION. To provide radiological safety and general health-and-safety support, a large amount of equipment and supplies had to be moved from the Nevada Test Site to the Shoal site. The following equipment was used:

--A remodeled 28-foot trailer for a first-aid station. (This was set up during the construction for site preparation, about five months before the test.)

--Twelve trailers, each equipped with eight air samplers.

--A personnel-decontamination trailer.

--Two 30-foot trailers for field offices c "check stations."

--A truck with a 1,000-gallon water tank and high-pressure pump and nozzle for decontaminating heavy equipment.

--A base-station trailer for housing portable radiation instruments, clothing, dosimeters and film badges, and supplies, and to serve as a check station to control entry into the test area. (This trailer was set up 500 feet from surface ground zero after the shot.)

--A mobile laundry trailer for decontaminating clothing. (About 1,050 coveralls and 2,400 pieces of protective equipment--boots, gloves, caps, respirators, etc.--eventually were decontaminated.)

--A mobile radiological-bioassay laboratory. (The lab and laundry were positioned half a mile from surface ground zero after the shot.)

The lab was equipped for routine analysis of air and water samples, and for bioassay by chemical analysis and gross fission-product counting. For gamma spectrometry, the U. S. Public Health Service analyzer in Fallon was used.

B. RADIATION-SURVEY AND SAMPLING METHODS.

1. PORTABLE-INSTRUMENT MONITORING.

a. Background Surveys. Monitors systematically surveyed the test area before the event to determine normal, background levels of radiation.

b. Postshot Surveys. Three teams made the initial radiation survey after the test, monitoring all onsite roads and stations. Radiation surveys were made and results (negative) recorded with reference to numbered stakes that had been placed along roads every quarter mile (in some cases, every tenth of a mile) before the test.

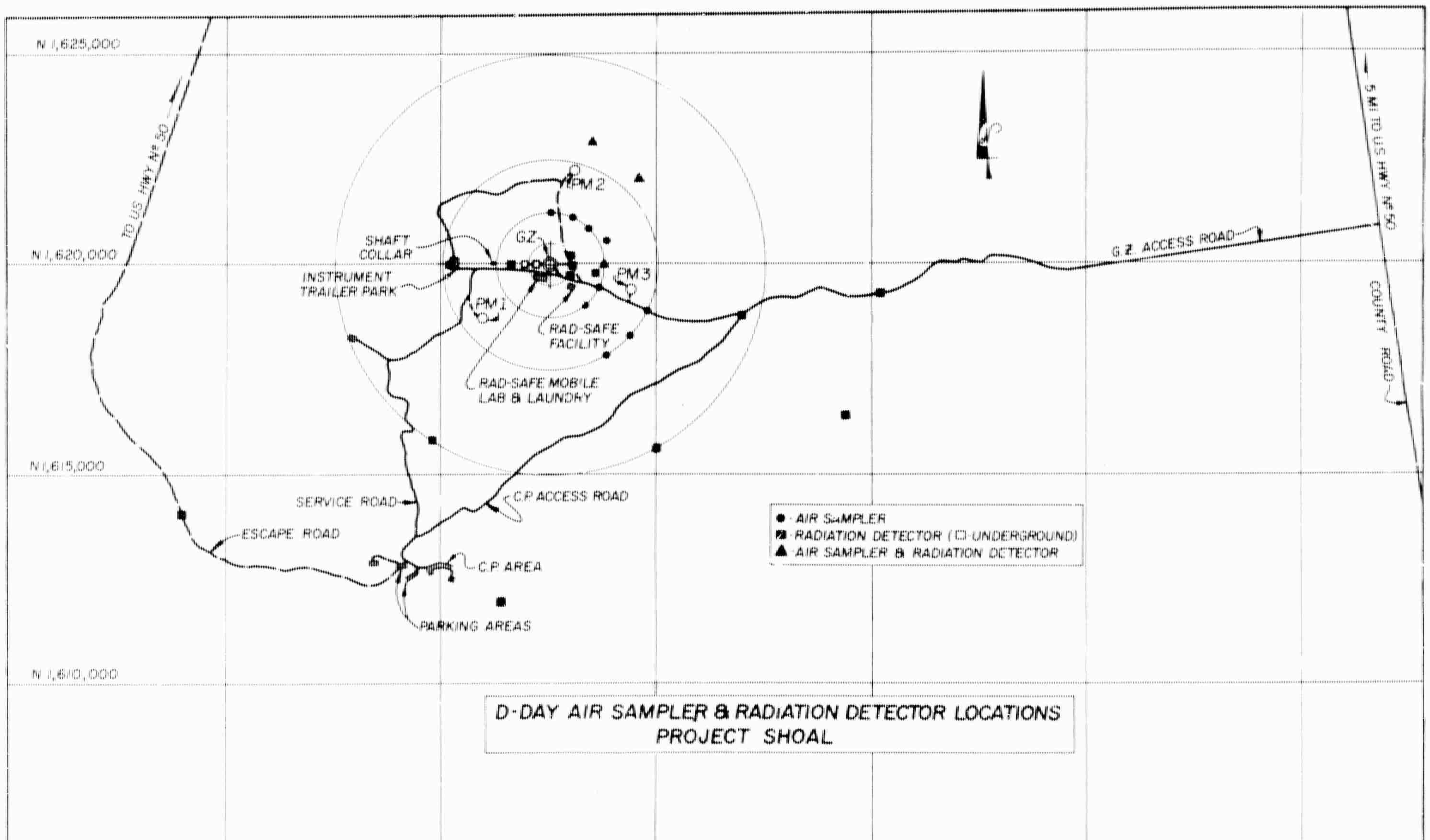
When drilling started, monitors were assigned to the drilling area continuously throughout the operation. They also monitored the general area, the effluent-exhaust (vent-line) system, and the people working in or leaving the radiation area.

c. Results. No radiation was detected on D Day. After postshot drilling started, monitors found radiation on and immediately around the drill rig and vent line only. Access to the area required control only on D Day and the last five days of drilling. Maximum amounts of gamma plus beta were 50 mrad/hr at the drill-hole casing, 3 mrad/hr at the drill-rig platform, and 5 mrad/hr at the first chip-and-dust-collection tank on the vent-line (see diagram, page 9.).

2. REMOTE MONITORING.

a. Preshot Preparation. Eighteen remote detectors for gamma monitoring were placed around the test area and hard-wire linked to readout consoles. Background radiation was measured and recorded before the test.

Two instruments in the main drift were damaged by the shock wave. The other 16 were positioned on the surface around, and at distances of 500 to 8,200 feet from, surface ground zero. (See diagram, page 5, for locations.)



D-DAY AIR SAMPLER & RADIATION DETECTOR LOCATIONS
PROJECT SHOAL

b. Postshot Monitoring. To measure radiation in and near the drilling area and inside the vent line, personnel placed radiation-monitoring detectors on the drill rig and at several locations along the vent system. To get a fast evaluation of gross radioactivity released into the atmosphere, they put four Geiger-Mueller detectors inside each vent-line exhaust stack. (See Section 6, Vent-Line Monitoring and Sampling.)

Some of the detectors that had been placed around the area before the test were relocated for close-in monitoring.

All readout stations were checked continually by monitors during the postshot phase.

c. Results. The 16 detectors encircling ground zero indicated no radiation above background levels either on or after D Day. (For results of vent-line monitoring, refer to Section 6, Vent-Line Monitoring and Sampling.)

3. STICKY-TRAY AND AREA FILM-BADGE SAMPLING.

a. Procedure. To collect samples of radioactive dust or other particulate matter, trays coated with a sticky substance were placed on stakes at fixed locations around the test area. Gamma film badges also were attached to these stakes. (See diagram, page 15, for locations.)

b. Results. There was no exposure to gamma radiation above the reportable limit (30 mR).

Sticky trays showed maximum radiation intensities of 5.3×10^{-4} μC of alpha, and 8.7×10^{-4} μC of beta, per square foot of surface area. Both alpha and beta activity were the result of the decay of natural thorium.

For complete data, see Table A, page 13.

4. PERSONNEL DOSIMETRY.

a. Film-Badge and Dosimeter Distribution. Before the event, all persons at the Shoal site were issued gamma film badges. After the event, self-read pocket dosimeters were given to all persons who entered the potential radiation area; gamma film badges also were exchanged when the need arose.

b. Results. No exposure to radiation was indicated by pocket dosimeters. No exposure was indicated by film badge for any person other than those who calibrated radiation-detection instruments. Here, the maximum exposure was 140 mR, received by a Radiological Sciences technician using a radioactive source for calibration.

5. AIR-SAMPLE COLLECTION.

a. Preparation. Twelve trailers--each with eight air-sampling heads that could run all together, in sequence, or singly for indefinite periods--were placed around the test area. The sampling heads contained a Whatman 41 prefilter and a charcoal-cartridge filter.

For the event, the trailers were situated along two arcs 1,250 and 2,500 feet downwind from ground zero. (See diagram, page 5, for locations.) After the event, they were relocated to encompass the drilling and vent-line areas. (See diagram, page 18.)

b. Sampling. The air samplers were started before the test. In each trailer, one sampler ran for 1 hour, then the next sampler for 1 hour, and so on for 8 hours, after which the cycle was repeated. This sequence lasted through D Day and until postshot drilling started.

After drilling started, one sampler in each trailer ran continuously, with the filters and cartridges changed every 8 hours, until drilling reached 600 feet. At that depth the samplers were changed back to sequential operations. Within this last period, the filters and cartridges were not changed until there was evidence of venting, or until a week had passed. During drilling operations, air samples

were collected continuously around the drill rig. (See diagram, page 18 .)

c. Results. Radiological Sciences technicians analyzed the filters and cartridges at the USPHS lab in Fallon; they found no significant concentrations of radioactive particles or gases. Maximum amounts of Iodine 131 were 7.2×10^{-3} μC per m^3 of air around the drill rig, and 8.0×10^{-4} $\mu C/m^3$ on the drill rig.

6. VENT-LINE MONITORING AND SAMPLING.

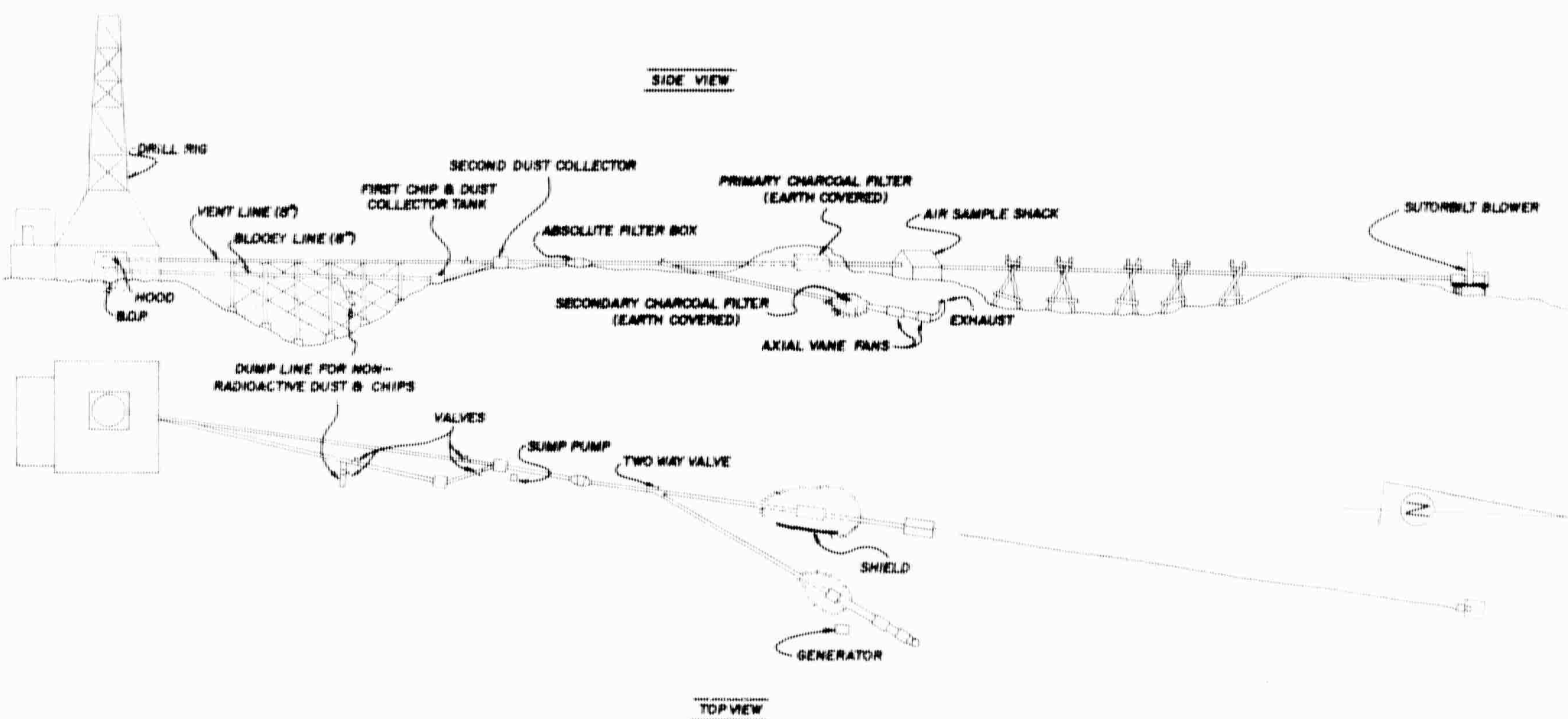
a. Description of the Vent-Line System. The effluent-vent-line system was an arrangement of vent pipes, filtering devices, blowers, and exhausts. Its function was to prevent radioactive matter--especially iodine--from escaping underground confinement and entering the atmosphere during postshot drilling. (See diagram, page 9, for illustration.)

The system accomplished this by first containing the high-pressure gases with a blowout preventer (BOP) during the postshot drilling. Then vent pipes transported the effluent away from the drilling area and through a series of filters, which trapped most of the radioactive matter. (The filters included two dust-and-chip-collection tanks; a box containing absolute filters, with prefilters to trap particulate matter; and a box ("charcoal bed") of 2,500 pounds of activated charcoal, covered with dirt.)

Finally, at the e... of the system, a blower drew the filtered effluent through the exhaust stacks.

An auxiliary system was available if the first blower failed. A secondary vent line branched off from the main vent line in front of the charcoal bed. (See diagram, page 9 .) The auxiliary line was connected to a box of 400 pounds of activated-charcoal filters, then to two axial-vane fans in succession, and finally to the auxiliary exhaust stack.

b. Monitoring Locations. Gamma detectors were placed at several locations in the vent-line system, as



POST SHOT DRILLING VENT-LINE SYSTEM
PROJECT SHOAL

explained below. (Refer to diagram, page 9, for locations.)

--Two scintillators were placed on the drill-rig air-exhaust line ("blooey" line) near its junction with the blowout preventer; their function was to detect the initial release of effluent. They were connected to alarms that sounded when certain levels of radiation were detected.

--A radiation-detector probe was situated at each of the following places: outside and near the bottom of the first dust-collection tank; on top of each charcoal bed; and on the vent line ahead of each exhaust stack.

--Geiger-Mueller detectors were put inside the exhaust stacks. They provided a fast evaluation of gross activity released into the atmosphere, but did not identify isotopes.

c. Vent-Line Samples. Samples to determine the types, quantity, and radioactivity of the gases (particularly iodine) inside the vent line were taken at two places: in front of the charcoal bed and in front of the exhaust stack (in the primary vent-line system).

The sampling apparatus consisted of a series of four filtering devices: a Whatman 41 filter; a charcoal cartridge; a desiccant (vapor-absorbing) cartridge; and two cold traps, each comprising an absorption tube filled with activated charcoal and immersed in a mixture of acetone and dry ice.

The Whatman filters trapped particulate matter; the charcoal cartridges absorbed most of the radioactive iodine; the desiccant cartridges absorbed water vapor; and the cold-trap absorption tubes captured inert gases.

Also, samples were taken directly from the vent system to determine the presence of toxic and explosive gases.

d. Results. Tables C-3, D, and E show the amounts of

Iodine 131, Xenon 131m, and Xenon 133 released through the system into the atmosphere. The figures were extrapolated from sample results. Total release based on this method was as follows: Iodine 131, 3.3×10^{-2} Curies; Xenon 131m, 2.1×10^{1} Curies; Xenon 133, 9.2×10^{1} Curies.

Results of samples taken in front of the charcoal bed are not given because the sampling apparatus was not functioning properly. The main function of the radiation-detector probes on the vent-line system was to warn of high radiation levels that might endanger people working near the system, rather than to provide continuous measurements. A second function was to help determine the duration of sampling periods. For these reasons, vent-line-monitoring data were not tabulated; also, the results from vent-line samples were considered most indicative of vent-line activity.

7. BIOASSAY.

a. Procedures. Urine specimens were obtained from a group of Project Shoal participants before the test --so a base line of normality could be determined-- and again at the conclusion of operations.

b. Results. No internal radiation exposure was indicated.

C. MISCELLANEOUS ACTIVITIES.

The following routine activities also were performed as part of the overall responsibility of the Radiological Sciences group:

--Demarcating areas of actual or potential radiation (radiation exclusion areas); controlling entry to these areas by establishing area control and, in the work area, by limiting entry to authorized persons.

--Decontaminating and providing clothing, and issuing it to all persons entering a radiation-exclusion area.

--Issuing self-read dosimeters, and film badges when necessary, to all persons entering a radiation area, and documenting their entry and exit.

--Maintaining raoiation-monitoring instruments.

--Decontaminating land near the surface-ground-zero drill hole and the catch basin. This was done by scraping the surface, mixing the contaminated soil with clean soil to reduce concentrations of radio- ctive material, and burying the soil under several feet of uncontaminated earth.

III. TABLES OF RADIATION MEASUREMENTS

A. ALPHA AND BETA ACTIVITY.

TABLE A: ALPHA AND BETA ACTIVITY PER SQUARE FOOT OF STICKY-TRAY SURFACE AREA

Stake No.*	Alpha** ($\mu C/ft^2$)	Beta** ($\mu C/ft^2$)	Stake No.*	Alpha** ($\mu C/ft^2$)	Beta** ($\mu C/ft^2$)
A-1	#	##	A-21	1.7×10^{-5}	##
A-2	3.5×10^{-5}	##	A-22	5.3×10^{-5}	3.5×10^{-5}
A-3	1.7×10^{-5}	##	A-23	4.4×10^{-5}	5.3×10^{-5}
A-4	1.7×10^{-5}	##	A-24	5.3×10^{-5}	##
A-5	#	##	B-1	1.7×10^{-5}	2.5×10^{-4}
A-6	1.7×10^{-5}	1.5×10^{-4}	B-2	1.7×10^{-5}	##
A-7	#	##	B-3	#	2.9×10^{-4}
A-8	#	8.4×10^{-5}	B-4	5.3×10^{-5}	3.6×10^{-4}
A-9	#	##	B-5	2.6×10^{-5}	2.6×10^{-5}
A-10	1.7×10^{-5}	##	B-6	3.5×10^{-5}	##
A-11	#	8.8×10^{-6}	B-7	3.5×10^{-5}	7.0×10^{-5}
A-12	#	2.8×10^{-4}	B-8	5.3×10^{-4}	2.5×10^{-4}
A-13	1.7×10^{-5}	2.5×10^{-5}	C-1	1.6×10^{-4}	8.1×10^{-4}
A-14	1.7×10^{-5}	2.9×10^{-4}	C-2	8.8×10^{-5}	3.5×10^{-5}
A-15	8.8×10^{-6}	2.5×10^{-5}	C-3	1.5×10^{-4}	5.9×10^{-5}
A-16	6.2×10^{-5}	3.3×10^{-4}	C-4	1.6×10^{-4}	2.4×10^{-4}
A-17	6.2×10^{-5}	5.5×10^{-5}	C-5	9.7×10^{-5}	1.8×10^{-4}
A-18	5.3×10^{-5}	##	C-6	1.9×10^{-4}	2.4×10^{-4}
A-19	6.2×10^{-5}	1.7×10^{-4}	C-7	1.2×10^{-4}	3.0×10^{-4}
A-20	3.5×10^{-5}	1.6×10^{-4}			

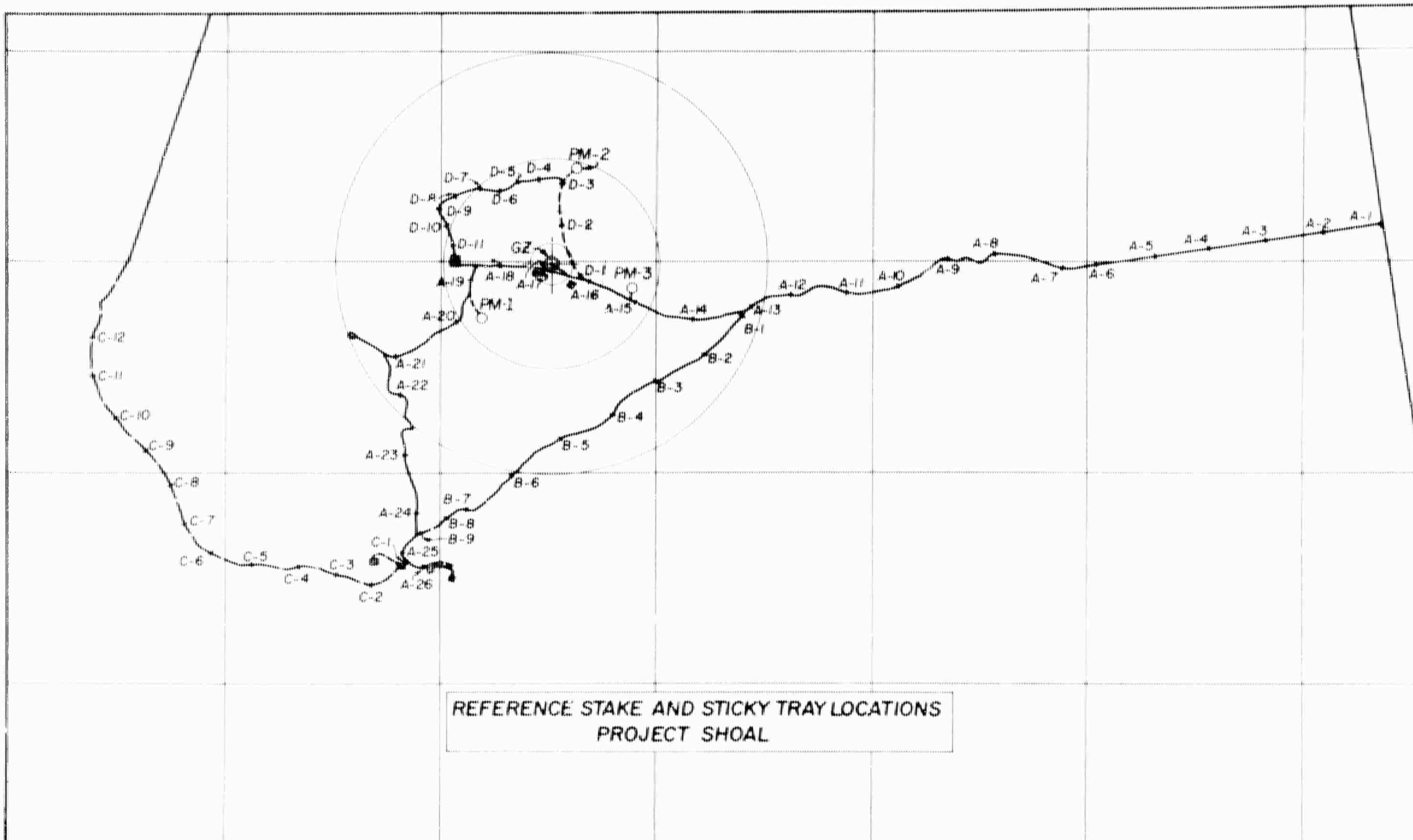
(Continued on next page)

(TABLE A CONT.)

Stake No.*	Alpha** ($\mu C/ft^2$)	Beta** ($\mu C/ft^2$)	Stake No.*	Alpha** ($\mu C/ft^2$)	Beta** ($\mu C/ft^2$)
C-8	9.7×10^{-5}	5.7×10^{-5}	D-4	8.8×10^{-5}	---
C-9	1.1×10^{-4}	6.0×10^{-4}	D-5	---	3.7×10^{-4}
C-10	1.3×10^{-4}	1.9×10^{-4}	D-6	8.8×10^{-5}	5.5×10^{-4}
C-11	1.3×10^{-4}	7.4×10^{-4}	D-7	1.5×10^{-4}	4.0×10^{-4}
C-12	9.7×10^{-5}	8.7×10^{-4}	D-8	1.4×10^{-4}	2.3×10^{-4}
D-1	9.7×10^{-5}	1.1×10^{-4}	D-9	9.7×10^{-5}	7.0×10^{-5}
D-2	1.7×10^{-5}	4.9×10^{-4}	D-10	7.9×10^{-5}	4.4×10^{-5}
D-3	1.4×10^{-4}	7.3×10^{-4}	D-11	8.8×10^{-5}	2.7×10^{-4}

Trays were placed 10/25, collected and counted 10/30.

* See diagram, pg. 15, for locations.
** All data were from decay of natural thorium.
# Less than 2.0×10^{-6} $\mu C/ft^2$, minimum detection limit.
Less than 1.0×10^{-6} $\mu C/ft^2$, minimum detection limit.



REFERENCE STAKE AND STICKY TRAY LOCATIONS
PROJECT SHOAL

B. GAMMA-PLUS-BETA ACTIVITY.

TABLE B: MAXIMUM DAILY LEVELS OF GAMMA PLUS BETA* AT THE DRILL-HOLE CASING, DRILL-RIG PLATFORM, AND CHIP TANK 1

Date	Mrad/hr in Air* (Casing)	Mrad/hr in Air* (Platform)	Mrad/hr in Air* (Tank)	Depth of Hole (Ft)	Notes
11/23	#	#	#	896	(1)
11/24	#	#	0.2	966	
11/25	0.5	0.5	#	970	
11/26	#	0.1	0.2	"	(2)
11/27	#	0.1	#	"	"
11/28	#	#	#	"	"
11/29	#	#	#	"	"
11/30	#	#	0.1	"	"
12/1	#	#	0.1	"	(3)
12/2	#	#	#	"	"
12/3	#	#	#	"	(4)
12/4	0.1	#	0.1	"	(2)
12/5	#	#	0.1	"	"
12/6	.1	#	#	"	"
12/7	#	#	0.1	"	(5)
12/8	#	#	#	"	"
12/9	#	#	#	"	(2)
12/10	0.2	0.2	1.2	1057	
12/11	0.1	#	1.2	1071	
12/12	#	#	2.0	1102	
12/13	0.1	#	5.0	1332	
12/14	0.1	0.1	4.0	1378	
12/15	0.7	2.0	3.5	"	(6)
12/16	16.0	1.3	0.3	"	(7)
12/17	50.0	3.0	0.2	"	(8)
12/18	7.0	0.8	1.5	"	(9)
12/19	12.0	1.0	0.1	"	(10)

* Measured with an Eberline E-500B GM tube, open shield.
\# Background radiation, less than 0.03 Mrad/hr.
(1) No radiation above background detected to date.
(2) Reaming hole.
(3) Out of hole.
(4) Fishing for tools.
(5) Grouting.
(6) Relieved pressure built up by drilling air.
(7) TV run.
(8) Vent line disconnected; repairs to casing.
(9) Casing repairs complete, vent line reconnected; coring.
(10) Coring completed; hood leaking.

C. IODINE 131 ACTIVITY.

TABLE C-1: IODINE 131 PER CUBIC METER OF AIR COLLECTED BY AREA AIR SAMPLERS DURING VARIOUS TIME PERIODS

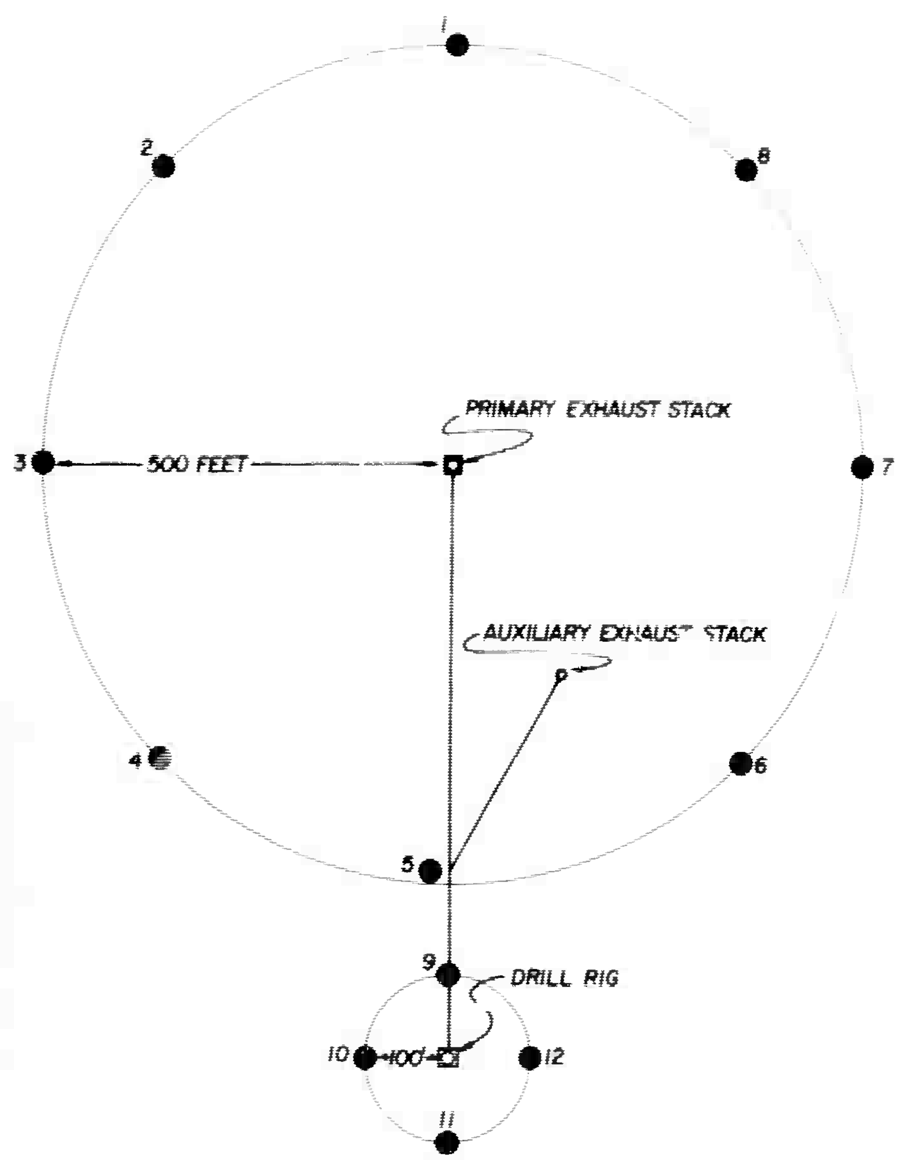
IODINE 131 AROUND THE EXHAUST STACK

Time Period	Iodine 131 ($\mu C/ft^3$) for Each Sampler							
	Air Samplers (See Page 18 for Locations):							
for Sampling	1	2	3	4	5	6	7	8
10/26-12/5	none	none	none	none	none	none	none	none
12/6-12/6	"	"	"	"	"	#	"	"
12/7-12/14	"	"	"	"	"	none	"	"
12/15-12/15	#	"	"	"	"	"	"	"
12/16-12/18	none	"	"	"	"	"	"	"
12/19-12/19	"	"	"	"	"	"	"	"

IODINE 131 AROUND THE DRILL RIG

Time Period	Iodine 131 ($\mu C/m^3$) for Each Sampler			
	Air Samplers (See Page 18 for Locations):			
for Sampling	9	10	11	12
11/10-11/28	none	none	none	none
11/29-12/1	"	"	"	7.2×10^{-3}
12/1-12/2	"	"	"	none
12/2-12/5	"	"	"	7.2×10^{-6}
12/6-12/6	#	"	"	7.2×10^{-6}
12/7-12/11	#	"	"	none
12/11-12/12	none	"	"	"
12/12-12/13	"	"	"	"
12/13-12/13	"	"	"	#
12/14-12/14	"	#	"	#
12/14-12/15	"	none	"	4.0×10^{-5}
12/15-12/15	2.1×10^{-6}	"	"	1.6×10^{-6}
12/15-12/16	none	"	"	none
12/17-12/17	"	"	"	9.5×10^{-7}
12/17-12/18	"	"	"	#
12/18-12/19	"	"	"	#

Less than 1×10^{-8}, minimum detection limit.



POST SHOT AIR SAMPLING LOCATIONS
PROJECT SHOAL

TABLE C-2: IODINE 131 IN AIR FROM THE DRILL PIPE

Time and Date Period Ended	I^{131} Released During Period ($\mu C/m^3$)	Time and Date Period Ended	I^{131} Released During Period ($\mu C/m^3$)
0015, 11/20	none	2220, 12/14	#
0745, 11/25	4.4×10^{-7}	2356, 12/15	6.7×10^{-4}
1545, 11/26	8.2×10^{-6}	0750, 12/16	#
1545, 11/27	none	1450, 12/16	5.4×10^{-6}
1500, 11/28	1.5×10^{-4}	1802, 12/16	#
1500, 11/29	none	2330, 12/16	#
2205, 11/29	1.1×10^{-5}	0730, 12/17	1.6×10^{-6}
2330, 12/10	none	1500, 12/17	8.0×10^{-4}
0335, 12/11	5.5×10^{-6}	2300, 12/17	2.4×10^{-6}
0800, 12/12	#	0730, 12/18	none
1500, 12/12	none	2300, 12/18	3.7×10^{-4}
0700, 12/14	none	0730, 12/19	2.3×10^{-6}
1540, 12/14	9.5×10^{-6}	1530, 12/19	3.3×10^{-6}
1630, 12/14	1.8×10^{-4}		

* These concentrations were not detected continually, but at short intervals when the drill string was uncoupled either to insert or remove drill pipe. The total amount of Iodine 131 released at these times is considered insignificant.

Traces detected; amount not measurable.

TABLE C-3: IODINE 131 RELEASED INTO THE ATMOSPHERE THROUGH THE VENT-LINE EXHAUST STACK

(Release was determined for consecutive periods--which began when the preceding period ended--by sampling the vent line near the exhaust stack, and extrapolating for the total.)

Time and Date Period Ended	I^{131} Released During Period (Curies)	Time and Date Period Ended	I^{131} Released During Period (Curies)
1530, 11/26	line closed	0900, 12/13	2.5×10^{-4}
1400, 12/2	none	2100, 12/13	2.0×10^{-4}
1330, 12/4	7.2×10^{-6}	0500, 12/14	4.4×10^{-4}
1330, 12/5	none	1030, 12/14	2.1×10^{-3}
0120, 12/6	2.5×10^{-6}	2013, 12/14	1.4×10^{-3}
1600, 12/6	5.8×10^{-6}	1000, 12/16	1.5×10^{-2}
0100, 12/7	7.4×10^{-6}	0100, 12/17	line closed
1400, 12/7	8.4×10^{-5}	0545, 12/17	1.9×10^{-4}
0130, 12/8	1.1×10^{-5}	1030, 12/17	7.8×10^{-4}
1330, 12/8	2.4×10^{-5}	1435, 12/17	8.7×10^{-4}
0030, 12/9	2.5×10^{-6}	0115, 12/18	7.0×10^{-4}
1330, 12/9	none	0915, 12/18	3.3×10^{-3}
1730, 12/10	1.7×10^{-6}	1732, 12/18	3.0×10^{-3}
0530, 12/11	1.9×10^{-5}	0200, 12/19	1.7×10^{-3}
1730, 12/11	1.7×10^{-5}	0950, 12/19	1.2×10^{-3}
2120, 12/12	none	1630, 12/19	[illegible].4 $\times 10^{-4}$

Total Curies of Iodine 131 Released: 3.3×10^{-2}.

D. XENON-131m ACTIVITY.

TABLE D: XENON 131m RELEASED INTO THE ATMOSPHERE THROUGH THE VENT-LINE EXHAUST STACK

(Release was determined for consecutive periods--which began when the preceding period ended--by sampling the vent line near the exhaust stack, and extrapolating for the total.)

Time and Date Period Ended	Xe 131m Released During Period (Curies)	Time and Date Period Ended	Xe 131m Released During Period (Curies)
1530, 11/26	line closed	1110, 12/16	none
1530, 12/11	none	0100, 12/17	line closed
2200, 12/11	8.9×10^{-1}	0530, 12/17	2.6×10^{0}
0930, 12/12	5.0×10^{-1}	1020, 12/17	1.3×10^{-1}
1530, 12/12	1.5×10^{0}	1435, 12/17	3.1×10^{-2}
2120, 12/12	1.2×10^{0}	0115, 12/18	5.0×10^{-2}
0900, 12/13	1.1×10^{0}	0915, 12/18	2.0×10^{0}
1300, 12/13	1.6×10^{0}	1732, 12/18	2.0×10^{0}
2100, 12/13	1.3×10^{0}	0130, 12/19	1.4×10^{-1}
0500, 12/14	1.7×10^{0}	0945, 12/19	4.0×10^{-2}
1030, 12/14	2.8×10^{-2}	1630, 12/19	8.6×10^{-1}
2015, 12/14	3.1×10^{0}		

Total Curies of Xenon 131m Released: 2.1×10^{1}.

E. XENON-133 ACTIVITY.

TABLE E: XENON 133 RELEASED INTO THE ATMOSPHERE THROUGH THE VENT-LINE EXHAUST STACK

(Release was determined as indicated in Table D.)

Time and Date Period Ended	Xe 133 Released During Period (Curies)	Time and Date Period Ended	Xe 133 Released During Period (Curies)
1530, 11/26	line closed	1530, 12/12	4.2×10^0
1400, 12/3	none	2120, 12/12	6.2×10^0
1330, 12/4	3.6×10^{-1}	0900, 12/13	1.1×10^1
0130, 12/5	2.0×10^{-3}	1300, 12/13	4.1×10^0
1300, 12/5	4.2×10^{-1}	2100, 12/13	9.5×10^0
0120, 12/6	9.0×10^{-2}	0500, 12/14	4.8×10^0
1330, 12/6	3.5×10^{-1}	1030, 12/14	8.9×10^{-2}
0130, 12/7	3.2×10^{-1}	2015, 12/14	6.9×10^0
1400, 12/7	5.0×10^{-3}	1110, 12/16	none
0130, 12/8	1.7×10^{-1}	0100, 12/17	line closed
1330, 12/8	2.0×10^{-2}	0530, 12/17	4.6×10^0
0030, 12/9	1.0×10^{-3}	1020, 12/17	1.8×10^0
1330, 12/9	1.0×10^{-3}	1435, 12/17	1.0×10^0
0530, 12/10	1.5×10^{-2}	0115, 12/18	1.8×10^0
1730, 12/10	1.4×10^{-1}	0915, 12/18	3.6×10^0
0530, 12/11	9.2×10^{-1}	1732, 12/18	4.6×10^0
1530, 12/11	1.3×10^{-1}	0130, 12/19	2.0×10^0
2200, 12/11	5.4×10^0	0945, 12/19	1.2×10^0
0930, 12/12	1.3×10^1	1630, 12/19	2.6×10^0

Total Curies of Xenon 133 Released: 9.2×10^1.

APPENDIX

OCCUPATIONAL AND NONOCCUPATIONAL INJURIES

Occupational	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
Abrasions	5	5	2	-	-	2	-	-	14
Blisters	1	-	-	-	-	-	-	-	1
Bruises	1	2	-	1	1	-	1	1	7
Cellulitis	-	-	-	-	-	1	-	-	1
Cuts	2	2	1	1	-	1	1	-	8
Eye irritation	1	1	-	1	-	2	-	1	6
Hands chapped	2	1	-	-	-	-	-	-	3
Infection	-	-	-	-	-	-	-	1	1
Puncture wound	-	-	-	1	-	-	-	-	1
Splinters	2	2	2	-	-	-	-	-	6
Sprains	2	2	-	-	-	-	1	-	5
Total	16	15	5	4	1	6	3	3	53

Nonoccupational	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Total
Abrasions	-	-	-	-	-	1	-	-	1
Athlete's foot	1	1	-	-	-	-	-	-	2
Bursitis	-	-	1	-	-	-	-	-	1
Common cold	2	2	-	-	2	-	-	-	6
Cuts	-	-	1	-	-	-	1	-	2
Diarrhea	-	1	-	-	1	-	-	-	2
Ear irritation	-	1	-	-	-	-	-	-	1
Eye irritation	1	-	1	-	-	-	-	-	2
Headache	2	3	-	-	-	-	-	-	5
Heartburn	1	-	-	-	-	-	-	-	1
Lips chapped	-	-	1	-	-	-	-	-	1
Muscle strain	-	-	-	-	-	-	1	-	1
Nose irritation	-	1	-	-	-	-	-	-	1
Pneumonia	-	-	1	-	-	-	-	-	1
Respiratory infection	-	-	-	1	2	3	3	-	9
Sinusitis	1	1	-	-	-	1	-	-	3
Skin rash	-	-	1	-	-	-	-	-	1
Stomach upset	-	1	1	-	-	-	-	-	2
Sunburn	-	2	-	-	-	-	-	-	2
Throat sore	2	1	1	-	-	-	-	-	4
Total	10	14	8	1	5	5	5	0	48
Grand Total	26	29	13	5	6	11	8	3	101

TECHNICAL REPORTS SCHEDULED FOR ISSUANCE BY AGENCIES PARTICIPATING IN PROJECT SHOAL

AEC REPORTS

Agency	Report No.	Project No.	Subject or Title
NBM	VUF-1001	33.2	Geological, Geophysical and Hydrological Investigations of the Sand Springs Range, Fairview Valley and Fourmile Flat, Churchill County, Nevada
SC	VUF-1002	40.5	Seismic Measurements at Sandia Stations
SC	VUF-1003	45.3	Hydrodynamic Yield Measurements
SC	VUF-1004	45.5	Device Support, Arming, Stemming and Yield Determination
SC	VUF-1005	45.6	Radiological Safety
EG&G	VUF-1006	60.4	Final Timing and Firing Report - Final Photo Report
USBM-PRC	*		Subsurface Fracturing From Shoal Nuclear Detonation
USWB	VUF-1008		Weather and Surface Radiation Prediction
USPHS	VUF-1009		Off-Site Surveillance
USBM	VUF-1010		Structural Survey of Private Mining Properties
USC&GS	VUF-1011		Seismic Safety Net
REECo	VUF-1012		On-Site Health and Safety Report

Agency	Report No.	Project No.	Subject or Title
RFB, Inc.	VUF-1013		Analysis of Shoal Data on Ground Motion and Containment
H-NSC	VUF-1014		Shoal Post-Shot Hydrologic Safety Report
H&N	VUF-1015		Pre-Shot and Post-Shot Structure Survey
H&N	VUF-1016		Test of Dribble-Type Structures
FAA	VUF-1017		Federal Aviation Agency Airspace Advisory
		DOD REPORTS	
SC	VUF-2001	1.1	Free Field Earth Motions and Spalling Measurements in Granite
SC	VUF-2002	1.2	Surface Motion Measurements Near Surface
** USC&GS	VUF-2300	1.4	Strong Motion Seismic Measurements
LPI	VUF-2600	1.6	In-Situ Stress in Granite
** STL	VUF-2400	1.7	Shock Spectrum Measurements
SRI	VUF-3001	7.5	Investigation of Visual and Photographic On-Site Techniques
SRI	VUF-3002	7.6	Local Seismic Monitoring - ela CLOUD GAP Program

TI	VUF-3003	7.8	Surface and Subsurface Radiation Studies
USGS	VUF-3004	7.9	Physical and Chemical Effects of the Shoal Event
ITEK	VUF-3005	7.10	Airborne Spectral Reconnaissance
BR Ltd.	VUF-3006	7.15	The Mercury Method of Identification and Location of Underground Nuclear Sites
NRDL	VUF-3007	7.16	Multi-Sensor Aerial Reconnaissance of an Underground Nuclear Detonation
GIMRADA	VUF-3008	7.17	Stereophotogrammetric Techniques for On-Site Inspection
ISOTOPES	VUF-3009	7.19	Detection in Surface Air of Gaseous Radionuclides from the Shoal Underground Detonation
*** USC&GS		8.1	Microearthquake Monitoring at the Shoal Site
**** GEO-TECH		8.4	Long-Range Seismic Measurements

* This is a Technical Report to be issued as PNE-3001 which will receive TID-4500 category UC-35 Distribution "Nuclear Explosions-Peaceful Applications"

** Project Shoal results are combined with other events, therefore, this report will not be printed or distributed by DTIE

*** Report dated March 1964 has been published and distributed by USC&GS

**** Report dated December 9, 1963, DATDC Report 92, has been published and distributed by UED

LIST OF ABBREVIATIONS FOR TECHNICAL AGENCIES

BR Ltd.	Barringer Research Limited Rexdale, Ontario, Canada
EG&G	Edgerton, Germeshausen & Grier, Inc. Boston, Massachusetts Las Vegas, Nevada Santa Barbara, California
FAA	Federal Aviation Agency Los Angeles, California
GEO-TECH	Geo Technical Corporation Garland, Texas
GIMRADA	U. S. Army Geodesy, Intelligence and Mapping Research and Development Agency Fort Belvoir, Virginia
H-NSC	Hazleton-Nuclear Science Corporation Palo Alto, California
H&N, Inc.	Holmes & Narver, Inc. Los Angeles, California Las Vegas, Nevada
ISOTOPES	Isotopes, Inc. Westwood, New Jersey
ITEK	ITEK Corporation Palo Alto, California
LPI	Lucius Pitkin, Inc. New York, New York
NBM	Nevada Bureau of Mines University of Nevada, Reno, Nevada
NRDL	U. S. Naval Radiological Defense Laboratory San Francisco, California
REECo	Reynolds Electrical & Engineering Co., Inc. Las Vegas, Nevada
SC	Sandia Corporation Albuquerque, New Mexico
SRI	Stanford Research Institute Menlo Park, California

RFB, Inc.	R. F. Beers, Inc. Alexandria, Va.
STL	Space Technology Laboratories, Inc. Redondo Beach Park, California
TI	Texas Instruments, Inc. Dallas, Texas
USBM	U. S. Bureau of Mines Washington, 25, D. C.
USBM-PRC	U. S. Bureau of Mines Bartlesville Petroleum Research Center Bartlesville, Oklahoma
USC&GS	U. S. Coast and Geodetic Survey Las Vegas, Nevada
USGS	U. S. Geologic Survey Denver, Colorado
USPHS	U. S. Public Health Service Las Vegas, Nevada
USWB	U. S. Weather Bureau Las Vegas, Nevada